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Study on the Synergistic Adsorption–Electrocatalytic Technology for Treating High-Concentration Ammonia Nitrogen Wastewater

Ammonia nitrogen (NH_3-N) is one of the most common and hazardous nitrogenous pollutants in wastewater, originating from a wide range of industries such as fertilizer manufacturing, coking, textile dyeing, pharmaceuticals, and intensive livestock farming. High concentrations of ammonia nitrogen pose serious threats to aquatic ecosystems and human health, primarily due to their toxicity and contribution to water eutrophication. Traditional treatment technologies, including air stripping, biological nitrification-denitrification, and chemical precipitation, often face challenges such as low efficiency, high operational costs, and potential secondary pollution, especially when treating high-strength ammonia nitrogen wastewater.

In recent years, synergistic adsorption–electrocatalytic technology has attracted growing attention for its advantages of high efficiency, low energy consumption, operational simplicity, and potential for complete pollutant mineralization. Adsorption processes can effectively reduce ammonia nitrogen concentrations in the initial stage, thereby alleviating the load on downstream treatment units. Electrocatalysis, on the other hand, can oxidize or reduce ammonia nitrogen into environmentally benign end-products such as nitrogen gas or nitrates via anodic or cathodic reactions. The combination of these two methods offers a synergistic effect, significantly enhancing overall treatment performance while optimizing energy usage and material efficiency.

This study focuses on the development of a coupled adsorption–electrocatalysis system for the effective treatment of high-concentration ammonia nitrogen wastewater. A series of experiments are designed to evaluate the effects of key parameters—including adsorbent type, electrode material, applied voltage, electrolysis duration, and pH—on ammonia nitrogen removal efficiency. Through orthogonal design and response surface methodology, the synergistic mechanism is explored, and the stability, regeneration potential, and transformation pathways of the system are assessed.

The results are expected to provide a high-performance and environmentally friendly solution for the deep treatment of industrial ammonia-rich wastewater, and offer theoretical and practical guidance for the development of integrated water treatment technologies under stringent discharge standards.